Skill Improvement of Wind Speed Monthly Forecasts

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1. OBJECTIVE

The aim of this work is to measure to which extent 10-m wind speed forecasts have improved in recent years by comparing the last publicly available version of **2017** of the monthly forecast systems of the European Center for Medium-Range Forecasts (**ECMWF-MFS**[1]) with the previous one, released in **2014**.

2. FORECAST SYSTEMS

Both ECMWF-MFS versions forecast 10-m wind speed up to 32 days in advance. The older version (v. **CY40R1**) is made up by **5 simulations** only and has a spatial resolution of **64 km**, while the more recent one (v. **CY43R3**) is composed by **11 simulations**, a resolution of **28 km** and takes into account **sea ice** too. Both systems were interpolated to a grid of the same resolution of reference dataset **ERA-Interim** (**70 km**). Selected hindcast period was **1996-2013** (**18 years**).

3. VALIDATION

6-hourly wind speed of Thursday hindcasts were averaged in weekly means for forecast times **5-11**, **12-18**, **19-25** and **26-32 days.** All weekly start dates within the same month were grouped together and weekly wind anomalies were measured separately for both hindcasts and observations to minimize drift[2,3]. Verification measures evaluated were: the Ensemble Mean Correlation[4] (**EnsCorr**), the Fair Ranked Probability Skill Score[4] (**FairRPSS**), the Fair Continuous Ranked Probability Skill Score[4] (**FairCRPSS**) and the **Reliability Diagram**[5].

4. RESULTS for all verification measures

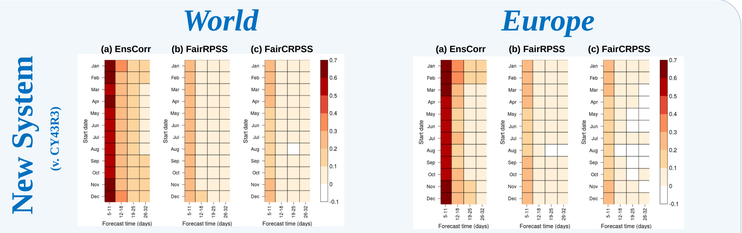


Figure 1. *Left:* (a) **EnsCorr**, (b) **FairRPSS** and (c) **FairCRPSS** for each start date (from January to December) and forecast time (four weeks) for the newer ECMWF-MFS; skill values were **averaged over the whole world** to measure the global skill values. Positive values correspond to cases when ECMWF-MFS beats climatological forecasts, while negative ones (in gray) when forecasts are less skillful than climatology. *Right:* averages for Europe only.

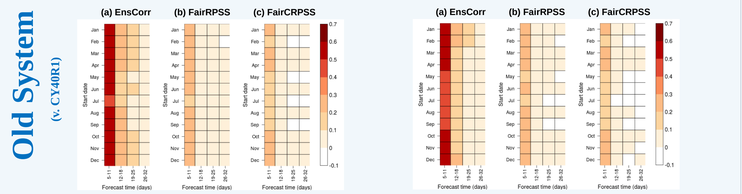


Figure 2. As figure 1, but for the older ECMWF-MFS (version CY40R1). Notice the sudden skill decrease from the forecast time 5-11 days to the following one, 12-18 days.

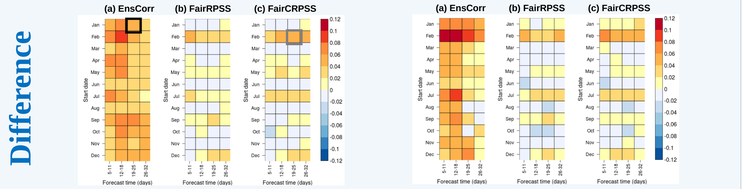


Figure 3. *Left:* differences between the world average scores of newer ECMWF-MFS (figure 1) and those of the older system (figure 2). Positive values represent an overall improvement over the older forecast system, while negative values an overall worsening of the skill score. *Right:* differences between average scores over Europe only. Scores inside the black and gray squares are also examined in detail respectively in sections 4 and 5.

5. IMPROVEMENT of EnsCorr in January

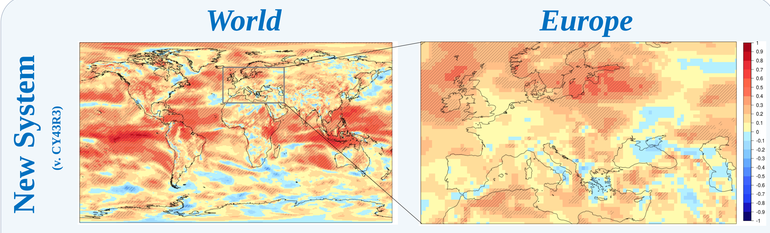


Figure 4. *Left:* global **EnsCorr** of 10-m wind speed for **January** start dates and **forecast time** of **19-25 days** for the newer ECNWF-MFS (version CY43R3). Red colors show areas where forecasts are better than simple climatological values, while hatched areas exhibit skill significantly at 95% level with a bootstrapping test. *Right*: zoom over Europe.

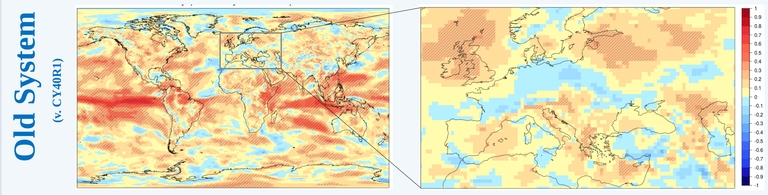


Figure 5. As figure 4, but for the older ECMWF-MFS (version CY40R1).

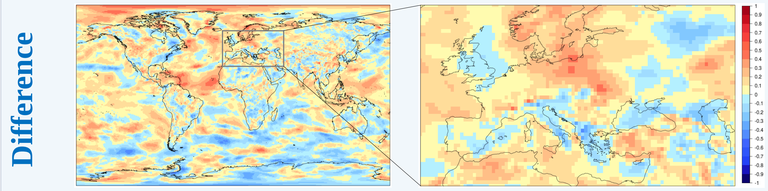


Figure 6. *Left:* difference between global **January EnsCorr** of 10-m wind speed of the newer ECMWF-MFS (figure 4) and of the older system (figure 5) for **forecast time 19-25 days**. *Right:* zoom over Europe. Positive values show regions with an improvement over the older forecast system, particularly most of the Central and North Atlantic and Europe.

6. IMPROVEMENT of FairCRPSS in February

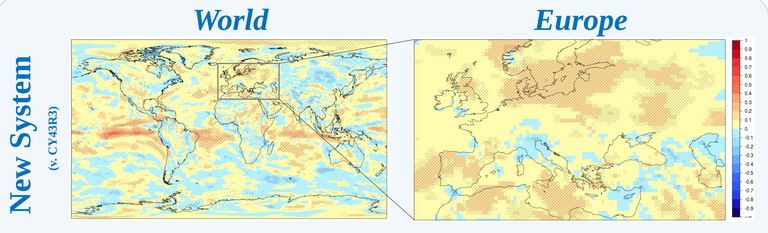


Figure 7. *Left:* global **FairCRPSS** of 10-m wind speed for **February** start dates and **forecast time** of **19-25 days** for the newer ECNWF-MFS (version CY43R3). Red colors show areas where forecasts are better than simple climatological values, while hatched areas exhibit skill significantly at 95% level with a bootstrapping test. *Right*: zoom over Europe.

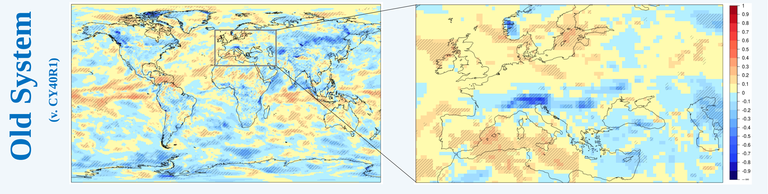


Figure 8. As figure 7, but for the older ECMWF-MFS (version CY40R1).

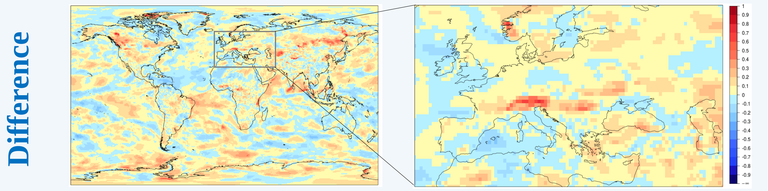
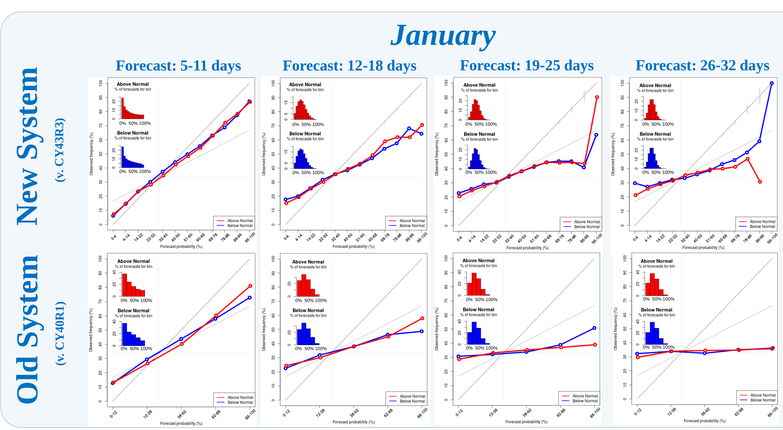


Figure 9. Difference between **February FairCRPSS** of 10-m wind speed of the newer ECMWF-MFS (figure 7) and of the older system (figure 8) for **forecast time 19-25 days**. Positive values show regions with an improvement over the older forecast system, particularly in areas where **skill was negative**: Asia, western Canada and in the Alpine range in Europe.

7. IMPROVEMENT of the Reliability Diagrams



Only start dates of **January** in **Europe** are shown, but similar results were found for all other start dates and at World scale. Diagrams of each system version have a different number *N* of intervals on the x-axis, as it depends on the total number of simulations of the hindcasts.

Generally, the newer system has a **higher reliability** for both terciles and for all start dates and lead times. In particular, most of the values of the intermediate forecast times of 12-18 days and 19-25 days are over/below the *no skill* line, respectively in case of the newer/older system.

Figure 10. Reliability diagrams[5] of the two ECMWF-MFS for both the **upper tercile** (red lines), representing above normal wind speed, and the **lower tercile** (blue lines), indicating below normal wind speed, in the **European region** (black box in figure 1) and for the two start months of **January** and for each of the four forecast times. Bisecting lines indicate perfect reliability, while black dotted lines show the No Skill line. The frequency distribution of the forecasts of the both terciles is shown in the histograms (*sharpness diagrams*).

8. CONCLUSIONS

- The average **EnsCorr always beats that of the older model**: it is **0.02 - 0.05** higher, both at World scale and at European scale.
- The averages of **FairRPSS** and **FairCRPSS** are generally very similar between the two model versions, both at World and at European scale. An exception was detected in **February** and **July**, when the new version always has higher skill than the previous one (up to **+0.08**).
- Generally, the skilll improvement doesn't follow any particular spatial pattern. However, in the case of **Europe**, the improvement of **FairCRPSS** in February previously described is mainly due to a better wind representation in the **Alpine mountain range**.
- The **Reliability Diagram** of the newer version has **substantially improved**, for all start dates and forecast times, and both at World and European scale.

[1]: Lynch, J., Brayshaw, J. & Charlton-Perez, A., 2014. Verification of European Subseasonal Wind Speed Forecasts, American Meteorological Society, (2006), pp.2978–2990.
[2]: Weigel, A.P., Baggenstos, D. & Liniger, M., 2008. Probabilistic Verification of Monthly Temperature Forecasts. American Meteorological Society - Monthly Weather Review, 136, pp.5162–5182.
[3]:Hudson, D. et al., 2011. Bridging the gap between weather and seasonal forecasting: intraseasonal forecasting for Australia. Quarterly Journal of the Royal Meteorological Society, 1989 (April), pp.673–689
[4]: Wilks, D.S., 2011. Statistical Methods in the Atmospheric Sciences 2nd ed., International Geophysics Series.
[5]: Hartmann, C.. et al., 2002. Confidence builders: evaluating seasonal climate forecasts from user perspectives. American Meteorological Society, (May), pp.683–698.

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